Power Grid Resilience

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Overview

- About REMI
- What is Resilience
- The Current State of U.S. Resilience
    - Winter "Ice" Storm
    - Background of U.S. Resilience
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- Q&A

About Us

Regional Economic Models, Inc. (REMI) was founded in 1980 on a transformative idea: ***government decision-makers should test the economic effects of their policies before they're implemented.*** We are the nation's leader in dynamic local, state and national policy modeling. Our clients use REMI models to perform rigorous economic analysis that critically influences local, state and national policies.

OUR CLIENTS:

Business Roundtable • Sandia National Laboratories • Ernst & Young • Texas Comptroller
University of Michigan • Tennessee Valley Authority • National Education Association
South Coast Air Quality Management District • Florida Department of Revenue
North Carolina Department of Commerce • Wyoming Department of Administration & Information
California Environmental Protection Agency • U.S. Army Corps of Engineers

Defining Resilience

Resilience: the ability to recover from or adjust quickly to a change in circumstances

Examples Include:

- Infrastructure failures (power outage, bridge collapse)
- Natural disasters (flood, wildfire, earthquake)
- Recessions/Industry shifts (loss of manufacturing jobs)

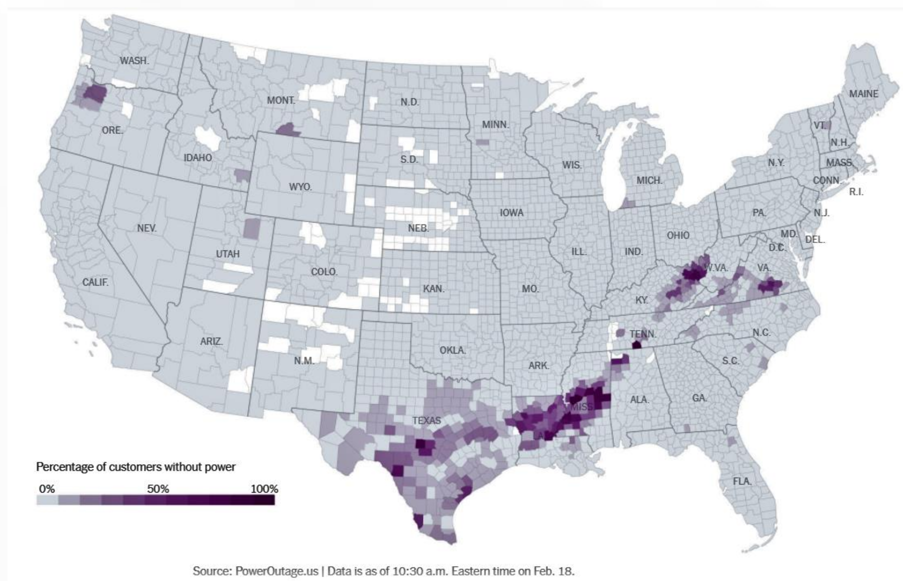
While federal aid is available, states must take primary responsibility for ensuring their resilience against disaster.

Why Model Resilience?

- Efficiency vs Resilience
- Economic modeling quantifies the value of creating and implementing resilient systems
- Making the case to invest in resilience
- Policy makers can be proactive when establishing policies to promote resilience at the local, state, and regional levels
- Resilience modeling informs and alerts decision-makers of the potential dangers of a non-resilient system

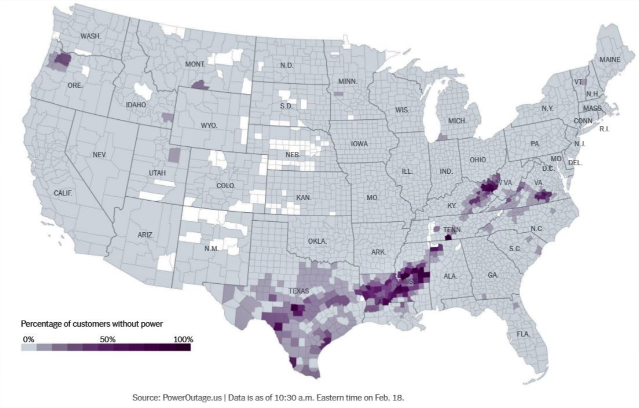
2021 Winter "Ice" Storm

- Uncertainty in coast-to-coast infrastructure resilience
- Number of power outages by state on Feb. 16, 2021:
  - Texas—4,325,098
  - Oregon—232,057
  - Louisiana—155,734
  - Kentucky—149,633
  - Oklahoma—202,272
  - West Virginia—100,730
  - Missouri—86,080
  - Virginia—75, 071



2021 Winter "Ice" Storm

- More than 4.5 million Texas homes and businesses were without power
- 11 deaths in Texas (23 deaths nationwide)
- An estimated $195 billion to cover damages in Texas
  - Oil and gas production
  - Food processing facilities and manufacturing plants
  - Property damage to homes and businesses

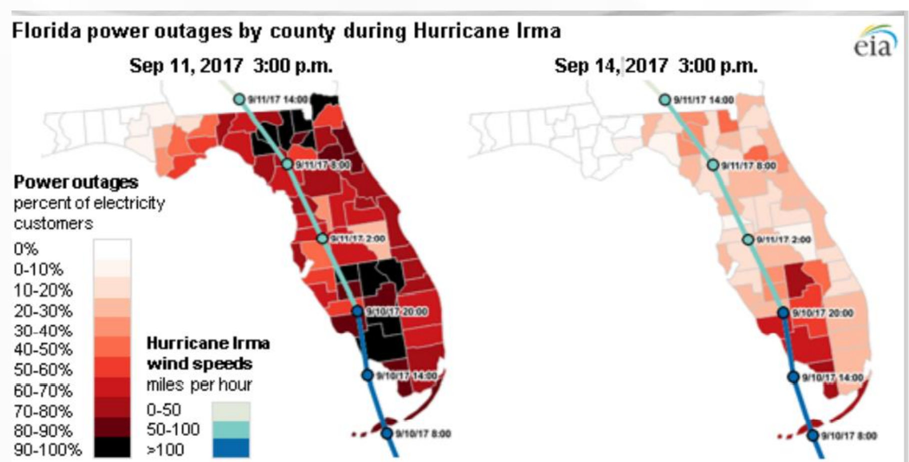


History of U.S. Resilience

Key challenges: climate change, infectious disease, terrorism – drive interest in resilience planning

"...the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow, no matter what kinds of chronic stresses and acute shocks they experience." -Rockefeller Foundation's '100 Resilient Cities' [2013]

Northeast Blackout 2003



Hurricane Irma 2017

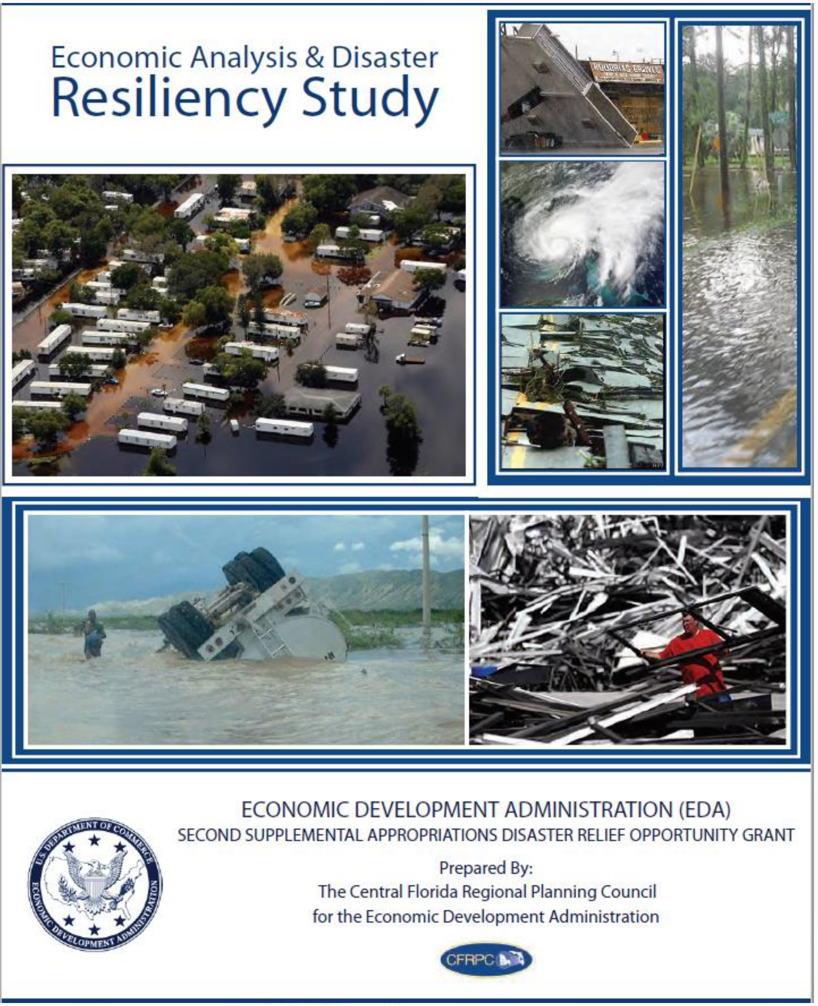
The Power Grid: black outs and brown outs

- What is a Black Out? A blackout is the **total loss of power** to an area and is the most severe form of power outage that can occur.

- What is a Brown Out? A **temporary dimming or reduction** in the use of electricity in a city to conserve electric power

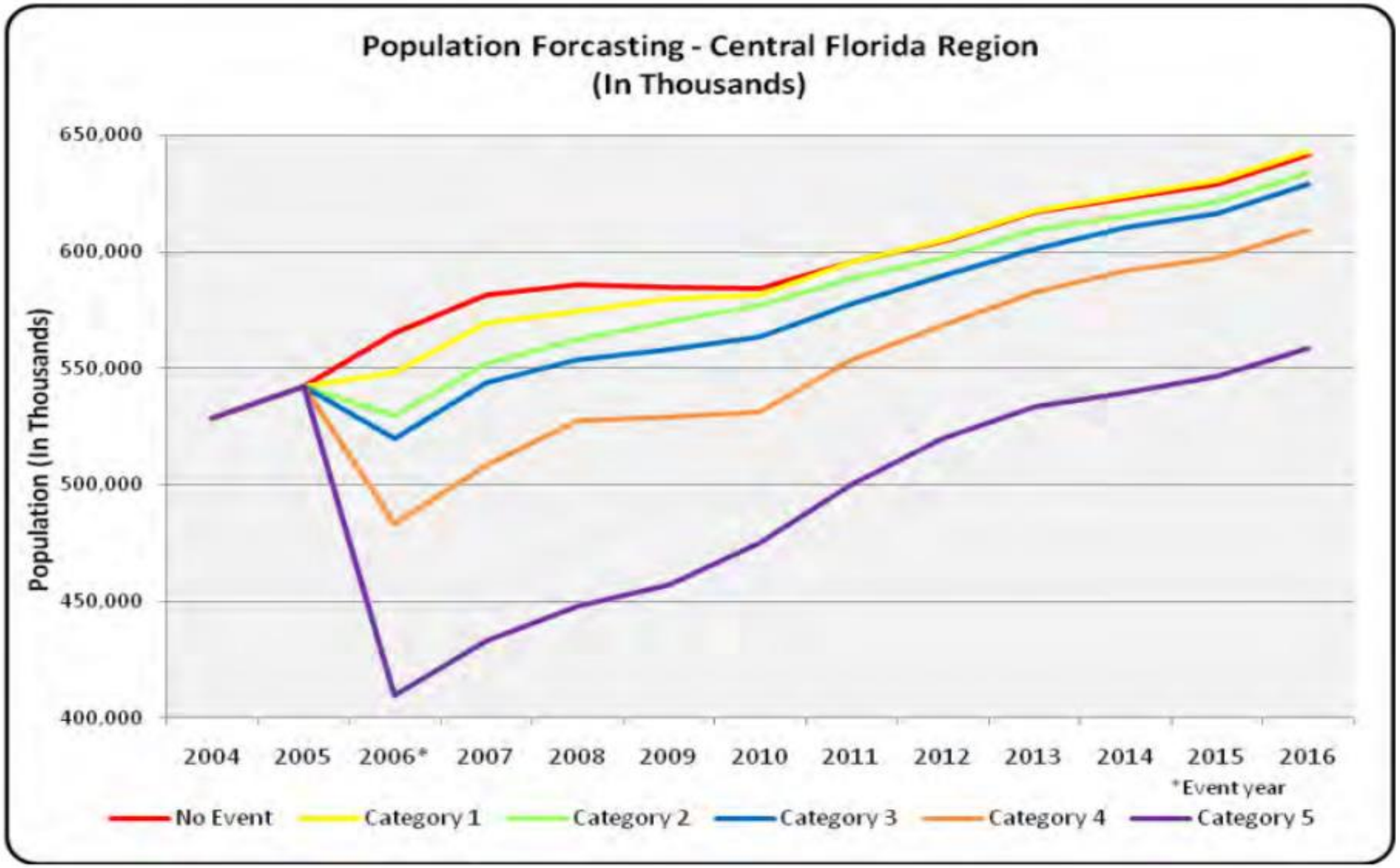
- The Cost of Power Grid Failure
  - Infrastructure: manufacturing, production, burst pipes, property damage
  - Productivity: closed businesses, immobile workers,
  - Health: storm related deaths, lack of filtered water

Economic Analysis & Disaster Resiliency Study



- ✓ The study provides an economic analysis of the effects of a **hurricane event** in Central Florida.
- ✓ Two **Recovery Scenarios:**
  - Normal recovery
    - Based on research of recovery experiences under similar situations
  - Accelerated recovery rates
    - Based on direct federal funding totaling $1 billion for each of the five counties
- ✓ Modeling simulated impacts to population, employment, regional domestic product, combined personal income, and sales tax revenue

Population



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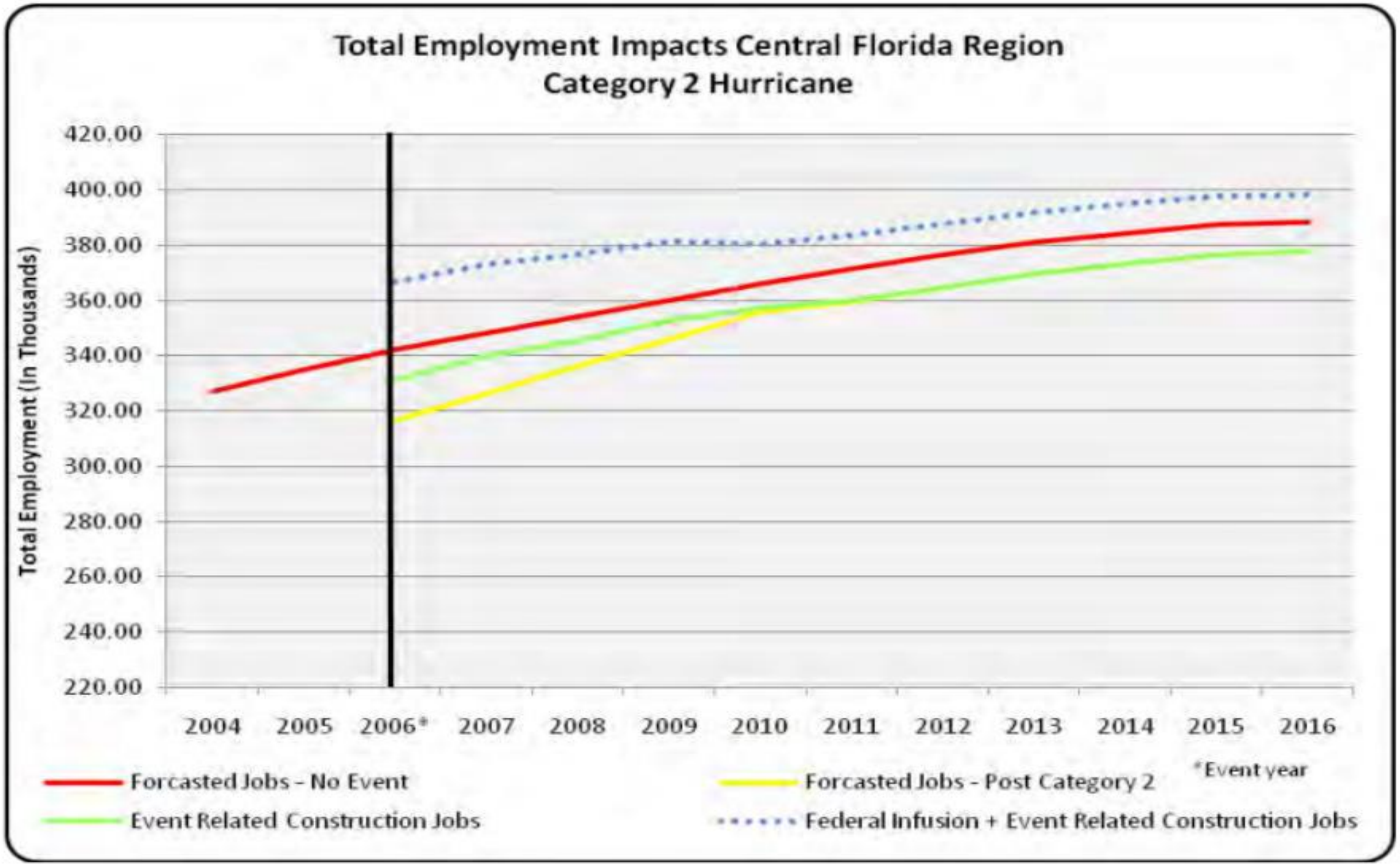
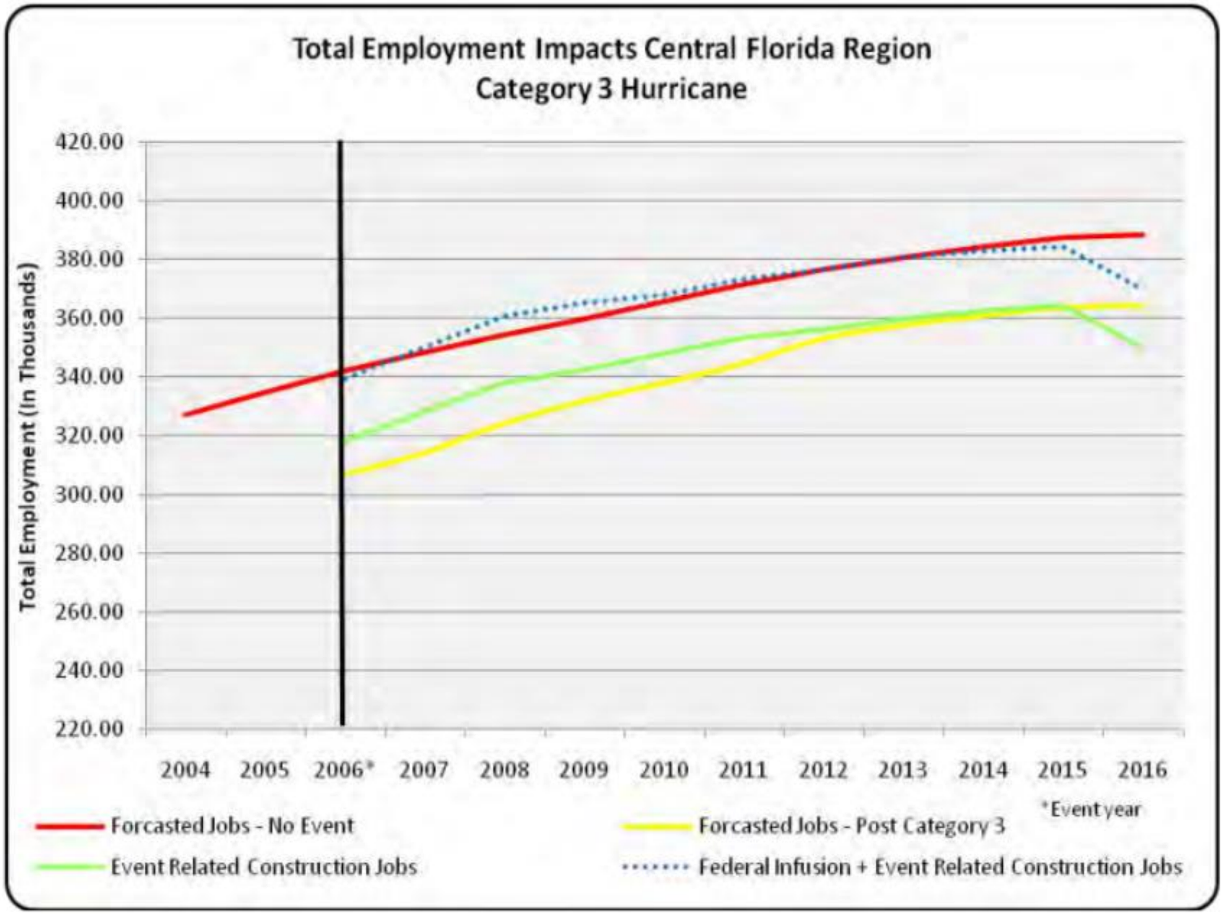
Total Employment Category 2

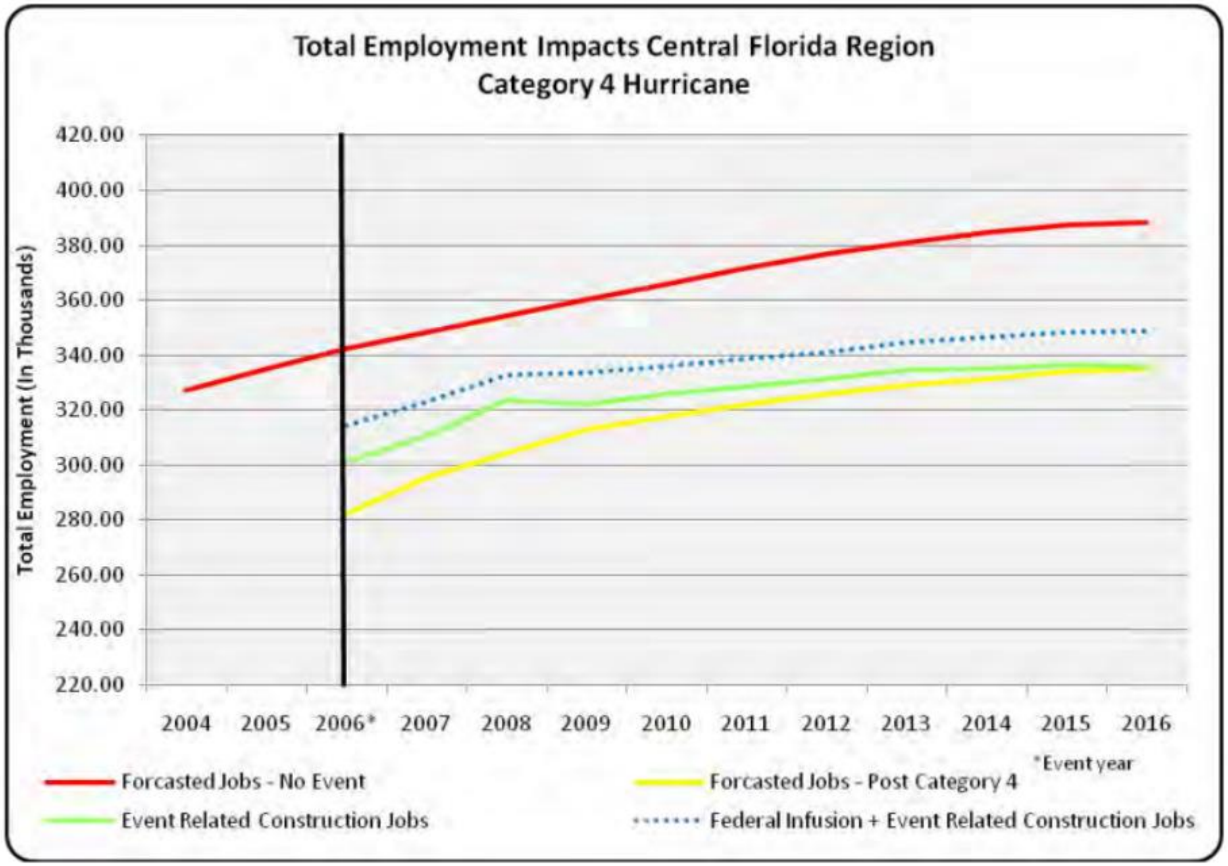


*what does **REMI** say?* sm

Total Employment Category 3



Total Employment Category 4



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Measuring Resilience with E3+: Dr. Adam Rose & Dan Wei

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Modeling Approaches for Resilience Tactics in REMI

Resilience Tactic	Simulation Method in REMI	Additional Notes
Export Diversion for Import Use	Adjust import and export shocks	Using goods that were intended for export as substitutions for the lack of availability of imports.
Conservation	Assume a 2% conservation rate: - Import shocks remain the same - Reduce the increased price of composite commodities by 2% (from 0.3% to 0.294%) - Export shocks remain the same	Conservation only helps deal with import disruption
Inherent Input Substitution	Not performed for this simulation	Inherent input substitution between labor and capital is captured by the REMI model automatically through its Cobb-Douglas Production Function. However, input substitution among intermediate goods must be performed manually. All adaptive input substitution must be calculated manually.
Import Substitution	Automatic	Inherent import substitution (replacing foreign imports with domestic production) is captured by the REMI model by increasing the share of domestic demand that is supplied from within the nation when there is a shock on imports.
Ship Rerouting	Adjust import and export shocks in different regions	Steering ships to other ports in California or along the Western Coast; can be simulated in a multi-region REMI Model.
Inventory Use	Adjust import shocks by sector	Can only help deal with import disruption; can be simulated by reducing the direct import disruption for a given commodity by the amount of inventory.
Production Recapture	Application of sectoral "Recapture Factors" to sectoral output changes	A side-calculation to adjust total output losses of each sector for rescheduling of production once the disruption is over.

- 90 Day Port Disruption
- Plugging in resilience methods and comparing to the baseline disruption forecast
- Examine Employment, GDP, Gross Output Results

***Source**: Modeling Economic Resilience to Disasters, Adam Rose and Dan Wei, Sol Price School of Public Policy and Center for Risk and Economic Analysis of Terrorism Events University of Southern California, June 2019*

Measuring Resilience with E3+: Dr. Adam Rose & Dan Wei

Resilience Tactic	Definition (Activities Involved)
Conservation	Maintaining production or service levels using lower amounts of an input
Resource Isolation	Modifying a portion of business operations to run without a critical input
Input Substitution	Replacing a production input in short supply with another
Inventories	Using emergency stockpiles and ordinary working supplies of inputs
Excess Capacity	Using plant or equipment that was idle
Relocation	Moving some or all of the business activity to a new location
Management Effectiveness	Improving the efficiency of business operations
Import Substitution	Obtaining needed production inputs from other regions
Technological Change	Improvising a production process
Production Recapture	Making up for lost production by working overtime or extra shifts
Resource Pooling/Sharing	Re-contracting, creating new partnerships, clearinghouses, etc.

Source: Modeling Economic Resilience to Disasters, Adam Rose and Dan Wei, Sol Price School of Public Policy and Center for Risk and Economic Analysis of Terrorism Events University of Southern California, June 2019

Measuring Resilience with E3^{+}: Dr. Adam Rose & Dan Wei

	Employment		GDP		Gross Output		Resilience Loss Reduction Potential (in terms of GDP)
	Impact (jobs)	% change from baseline	Impact (billions 2016$)	% change from baseline	Impact (billions 2016$)	% change from baseline	
Base Case	-105,480	-0.442%	-10.9	-0.429%	-14.4	-0.306%	
w/ Export Diversion	-76,450	-0.320%	-6.9	-0.271%	-6.8	-0.144%	36.9%
w/ Conservation	-102,070	-0.428%	-10.5	-0.416%	-13.8	-0.293%	3.1%
w/ Production Recapture	-63,852	-0.268%	-6.6	-0.260%	-8.7	-0.185%	39.5%
w/ Combined Resilience*	-44,217	-0.185%	-4.0	-0.156%	-3.7	-0.079%	63.6%

*Resilience improvements are not additive because of overlaps.

Source: Modeling Economic Resilience to Disasters, Adam Rose and Dan Wei, Sol Price School of Public Policy and Center for Risk and Economic Analysis of Terrorism Events University of Southern California, June 2019

Measuring Resilience with E3$^+$

E3$^+$ can produce an automatic calculation discussing resilience through a forecast's “Resiliency Report”

**This compares a no-action baseline disaster scenario to a resilience investment scenario*

The model produces a **Resilience Loss Reduction Potential** figure:

$$\textbf{RLRP} = \frac{\textit{Avoided Losses}}{\textit{Maximum Potential Losses}}$$

Source*: Modeling Economic Resilience to Disasters, Adam Rose and Dan Wei, Sol Price School of Public Policy and Center for Risk and Economic Analysis of Terrorism Events University of Southern California, June 2019*

Model Scenario

Scenario 1: Resilience Scenario

- Direct Power Outage Shock
- E3+ Resiliency Module

Scenario 2: Electric Infrastructure Improvement Plan

- Improve reliability of electric power
- Eg. replace aging substation equipment

Scenario 1

Concept: Power outage shock with versus without resilient electric system

Methodology:

- 1% and 0.5% Downward revision in baseline Output for 2021-2022 (control forecast)
  - Direct shock impact
  - Affect all industries
- 0.5% Upward increase in simulation Output for 2021-2022 (resilient forecast)
  - Cushion from resilient system

Scenario 2

Concept: Economic impacts of investing in electric infrastructure

Methodology:

- Invest approximately $1 billion for year 2021-2025
  - Assume investment will last five years
  - Increase industry sales for utility system construction
- Increase business costs savings for commercial and industrial sectors
- Increase property tax and electricity rate

Scenario 2 - Variables

- Detailed industry sales
  - Power and communication structures sector
- Production Cost
  - 66 non-farm private sectors
- State and Local Government Spending
  - Local government
- Consumer Price
  - Residential
- Fuel Cost
  - Commercial
  - Industrial

MODEL DEMONSTRATION

Conclusions

- Resilience is necessary.
  - Avoided loss

- Economic modeling can help quantify resilience.
  - Clarify, Calculate, Communicate

Q&A

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Citations

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- • U.S. power outages by state February 2021 | Statista
- Hurricane Irma and 2003 Blackout maps
- *Economic Analysis and Disaster Resiliency Study, Economic Development Administration, Central Florida Regional Planning Council*
- *Modeling Economic Resilience to Disasters, Adam Rose and Dan Wei, Sol Price School of Public Policy and Center for Risk and Economic Analysis of Terrorism Events University of Southern California, June 2019*